

Regulation of oil and gas reserves reporting in Saudi Arabia: Review and recommendations

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ABSTRACT

The regulatory framework and guidelines for reserves reporting in Saudi Arabia are reviewed – the ongoing privatization process of the national oil company (Saudi Aramco) will benefit from the establishment of transparent asset appraisal rules. Previously, Saudi oil reserves were exclusively reported to the Organization of Petroleum Exporting Countries (OPEC) as mandated by confidential considerations and internal policies of the Saudi government. Truly independent appraisal of oil and gas reserves as commonly performed by oil and gas investment analysts becomes increasingly relevant when national oil and gas companies are seeking to privatize and must gain the trust of the international investment community. Under such scenarios the regulation of – and compliance with – the governing reserves reporting guidelines need to be conducted with the utmost transparency. Successful monetization of the corporate asset value via bond issues and initial public offerings (IPO) to potential new shareholders critically depends on independent reserves appraisals. Some of the complexities of reserves estimations for a national oil company, such as Saudi Aramco, making the transition – from a formerly wholly state-owned enterprise to a public-private-partnership company – are highlighted. Recommendations are given for improved reserves reporting governance.

1. Introduction

This study underlines the importance of establishing and adopting an unambiguous regulatory framework for reserves reporting in Saudi Arabia, to improve transparency about the permissible assumptions in the estimation and reporting of domestic oil and gas reserves by petroleum producing companies active in the country. Around the globe, national reserves reporting frameworks and guidelines play an important role in how hydrocarbon producers aggregate and estimate their oil and gas reserves.

Prior to the privatization plans of Saudi Aramco (the Kingdom's national oil company), statements on domestic oil reserves were exclusively made by representatives of the Saudi government, commonly via official bulletins and press conferences held at the Organization of Petroleum Exporting Countries (OPEC). Until recently, public disclosures about hydrocarbon reserves in the Kingdom of Saudi Arabia have been a sovereign prerogative supremely reserved to the government. Fig. 1 gives a time series for the proved oil reserves of Saudi Arabia as reported by the government to the Organization for Oil Producing and Exporting Countries (OPEC). The Kingdom's oil reserves have been growing,

rather than declining, due to the combined results of new field discoveries and improved recovery factors in existing fields, consequent to technological advances.

As of 2019, Aramco first publicly released its 'own' reserves estimations in a globally distributed Investor Prospectus (2019), with updates in Aramco's annual reports for FY-2017-2020. Noteworthy, a slight decline has occurred in Aramco's reserves over the past four reporting years, which have a higher granularity than in any previous reserves reporting to OPEC by the Saudi government (Table 1). The reserves are split out into three product categories: (1) oil and condensate volumes, (2) natural gas liquids (NGL), and (3) natural gas. Together, these future product streams can be reported as oil-equivalent reserves. As of December 31, 2020, proved reserves were 255.2 billion barrels of oil equivalent.

Aramco's annual reports for FY-2017-2020, in addition to specifying the portion of reserve volumes leased to the company, also specify the total reserves owned by the Saudi government as the sovereign wealth custodian of the Kingdom of Saudi Arabia (Table 2). Evidently, Aramco presently acts as the assigned reserves reporting agency for the Kingdom. The reserves in Table 2 comprise all producible reserves

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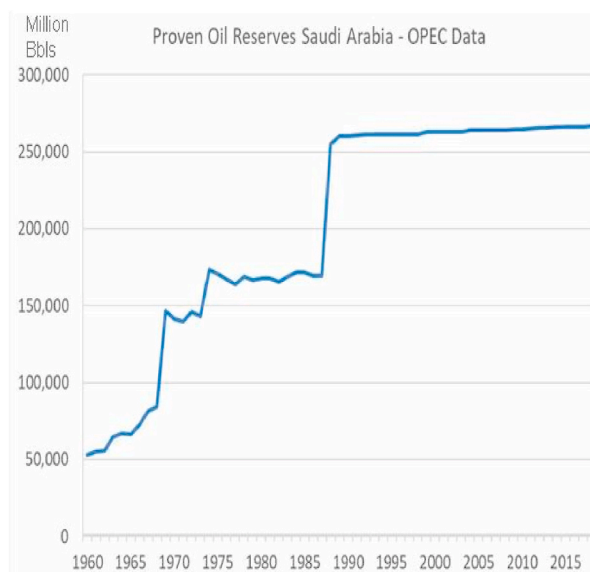


Fig. 1. Proved oil reserves reported by Saudi Arabia to OPEC for the period 1960–2019 (based on OPEC primary data).

commercially attributed to Aramco (Table 1) under the concurrent 60-year concession period granted by the government to Saudi Aramco in 2017, which is due to expire December 31, 2077. The extra reserves in Table 2 as compared to Table 1 occur in proven fields that are (as of the reporting date) assumed to be produced beyond the current concession expiry date of December 31, 2077. An example would be the supergiant Ghawar field which will not be depleted for over at least another Century.

The detailed reserves numbers of Tables 1 and 2 were publicly released first with the privatization announcement of Aramco's 2019 Investor Prospectus, which included reserves estimations for the end of fiscal years (FY)-2017 and FY-2018. The company has since released several updates on the development of its oil and gas reserves in Annual Reports for FY-2019 and FY-2020. The differential in the reserves reported in Tables 1 and 2 is made explicit in Table 3. The value of the reserves in Table 3 is not currently attributable to Aramco and therefore left outside its purported privatization value estimated at \$2 trillion (see details in Weijermars and Moeller, 2020). The Kingdom's 81.7 billion Bbls non-concessional oil equivalent reserves as of Dec 31, 2020 (Table 3) are equivalent to 32% of Aramco's reported reserves as of Dec 31, 2020 (Table 1), meaning that the Saudi Government has an additional approximate hydrocarbon asset value of \$640 billion to its disposal, in excess of its stake in Aramco's asset value as majority shareholder.

Any new releases of estimations of proved reserves by Aramco and the government of Saudi Arabia are of great interest to – and increasingly subjected to the scrutiny of – the global investment community, because most of the worth of any oil and gas company resides in its oil and gas reserves (Seba, 2008; Wright, 2015). Therefore, providing maximum transparency about both the reserves inventory and the governing reserves reporting guidelines has become increasingly

important, also for Aramco. The company management, in investor calls of spring 2020 and 2021, was extensively quizzed by investment analysts about its strategic choices, field development investment decisions and reserves replacement plans. Evidently, continued transparency is necessary for building sustained investor trust and for maximizing company asset values when issuing new bonds and equity tranches as part of the on-going privatization process.

Gas and liquid reserves of petroleum producing companies are routinely appraised by investment analysts at resource-based finance institutions (Weijermars, 2012; Weijermars and Watson, 2011; Weijermars et al., 2018). Such appraisals are necessary to identify the most attractive investment opportunities from the perspective of the lender of field development financing cost. The borrowing companies – international oil companies and independent oil and gas operators – upon having secured the required capital, can then take their final investment decisions to develop new target formations and thereby declare the contingent resources in their leases as reserves.

The development and appraisal of oil and gas resources is a technically complex process, with many decision gates (Fig. 2). What is typically done is gathering more information on every aspect of the asset to be developed, in order to reduce the uncertainty and quantify the project's risks. In the generic workflow diagram of Fig. 2, the final investment decision is taken at Decision Gate 3 (DG-3), which is when the financing of the asset must be secured by company management. At that point, enough information must have been gathered by a petroleum company to demonstrate that the new project meets the requirements for return on investment and to cover the cost of capital. In the case of oil and gas companies, the investments made create new hydrocarbon reserves which are capitalized on the balance sheet of the company. The newly added assets lead to gains in the worth of the company, assuming that the value of the newly booked asset exceeds the capitalized cost of any debt assumed to acquire the assets.

Prior privatizations by major national oil companies, first partly into so-called public-private-partnership companies – and sometimes subsequently wholly privatized – commonly involves listing on a global stock market like the New York Stock Exchange (NYSE) or major local markets. This provides companies access to a larger base of potential investors. Past examples are Rosneft (75.16% State), Petrobras (32.2% State), ENI (30% State), Equinor (70.9% State), ONGC (74.14%), and OMV (31.5% State) (2005 data benchmarked in Weijermars, 2009). When listing on NYSE (e.g., ENI, Equinor), those partly privatized national oil companies will need to file annual reports to the Security and Exchange Commission (SEC), which requires compliance with the very specific reserves reporting guidelines issued by the SEC (see later).

The ongoing privatization process of Saudi Aramco has indeed prompted the company to describe – to potential investors and shareholders – which portion of the oil and gas reserves owned by the Saudi government (Table 2) has been granted via extraction leases to the company (Table 1). The remainder of this study reviews some of the complexities of reserves reporting for oil companies making the transition from a formerly wholly state-owned enterprise to a public-private-partnership company, and then proceeds to explain – based on our in-depth assessment of reserves reporting guidelines – which aspects can be improved in the Kingdom of Saudi Arabia to meet investor community expectations. In-depth study of the reported reserves reveals that

Table 1
Stated hydrocarbon reserves attributable to Saudi Aramco under the current 60-year concession.

	1980–1987	1988–2016	Dec 31, 2017 (1)	Dec 31, 2018 (1)	Dec 31, 2019 (2)	Dec 31, 2020 (3)
Saudi Aramco						
Oil equivalent (billion Bbls)	N/A	N/A	260.2	256.9	258.6	255.2
Oil and condensate Reserves (billion Bbls)	N/A	N/A	204.8	204.0	201.9	198.8
NGL (billion Bbls)	N/A	N/A	26.0	25.4	25.7	25.2
Natural Gas (Tcf)	N/A	N/A	181.0	185.7	190.6	191.6

Sources: (1) Aramco Prospectus April 1, 2019 (page 84); (2) Aramco Annual Report FY 2019; (3) Aramco Annual Report FY 2020.

comprehensive reserves reporting guidelines can be further developed in the Kingdom (see Section 6). Such comprehensive guidelines, when developed will help avoid any doubt about the nature of numerous implicit reporting assumptions and choices made in Aramco's reserves estimations released in the public domain in its various reports (Table 1).

2. Reporting and non-reporting companies

The merits of privatizing Aramco have been carefully weighed by the Saudi government over an extended period. Detailed preparatory studies (2015–2018) and a first bond issue in 2019, were followed by an initial purchase offering (IPO) for a small portion of Aramco shares in 2020 (Weijermars and Moeller, 2020). Aramco, the corporate beneficiary of the privatization process, financed the IPO study, and the subsequent syndication of a \$12 billion bond offering, at an estimated total cost of \$0.5 billion in consultancy fees for the overall privatization guidance by a consortium of global banks and restructuring advisors (Weijermars and Moeller, 2020). The benefit to the Saudi government, as Aramco's sole shareholder at the time of the share flotation, was a one-time dividend, while the company gained access to new capital from the issuance of bonds and flotation of a minor equity stake (for details, see Weijermars and Moeller, 2020).

Saudi Aramco shares are currently listed on Tadawul, the Riyadh-based trading hub, which has not yet issued reserves reporting guidelines for energy companies. In contrast, oil and gas companies stock-listed in the US must diligently adhere to the reserves reporting guidelines of the Securities and Exchange Commission (SEC) of the New York Stock Exchange (NYSE). Once listed on NYSE, companies must strictly follow the SEC reserves reporting guidelines and are subject to SEC auditors' scrutiny for compliance. Independently, auditors from investment banks will do the same. The scrutiny of SEC auditors does not apply to so-called privately held companies not listed on NYSE. For non-listed companies, a final investment decision for field development is often sufficient to classify a former contingent hydrocarbon resource as a new reserve.

National Oil Companies (NOCs) like Saudi Aramco, especially after its step toward privatization in 2020 (Weijermars and Moeller, 2020), will not have to abide to transparency required by SEC-style reporting rules if not listed on NYSE. According to NYSE-SEC reserves reporting guidelines, only proved reserves (with an estimated 90% certainty that those volumes will be recovered in the future) must be reported and may be assigned a value. Reporting of probable (50% certainty) and possible (10% certainty) reserve volumes is optional, but any valuation of those volumes may not be mentioned in the company's mandatory annual report filings to the SEC. Major companies (like Shell) do not report the probable and possible reserves categories, because only the proved portion is of immediate interest to the SEC and the global investor community.

There are many smaller US start-up oil and gas companies not listed on NYSE, which nevertheless will have to produce evidence of the volume and value of their reserves to claim reserves and attract capital based on reserves collateral via so-called reserves-based lending (Weijermars et al., 2018). For such non-listed companies, a final investment decision is sufficient to classify a contingent resource as a reserve.

Table 2

Hydrocarbon reserves of Kingdom of Saudi Arabia as per reporting dates and sources quoted.

	1980–1987 (1)	1988–2016 (1)	Dec 31, 2017 (2)	Dec 31, 2018 (2)	Dec 31, 2019 (3)	Dec 31, 2020 (4)
Kingdom of Saudi Arabia						
Oil equivalent (billion Bbls)			332.1	336.2	336.7	336.9
Oil and condensate Reserves (billion Bbls)	~170	~260	260.8	261.5	261.5	261.5
NGL (billion Bbls)			35.1	36.1	36.0	35.9
Natural Gas (Tcf)			224.4	233.8	237.4	238.8

Sources: (1) OPEC data; (2) Aramco Prospectus April 1, 2019 (page 84); (3) Aramco Annual Report FY 2019; (4) Aramco Annual Report FY 2020.

Table 3

Non-convictional hydrocarbon reserves of Kingdom of Saudi Arabia as per reporting dates.

	Dec 31, 2017	Dec 31, 2018	Dec 31, 2019	Dec 31, 2020
Kingdom of Saudi Arabia				
Oil equivalent (billion Bbls)	71.9	79.3	78.1	81.7
Oil and condensate Reserves (billion Bbls)	56.0	57.5	59.6	62.7
NGL (billion Bbls)	9.1	10.7	10.3	10.7
Natural Gas (Tcf)	43.4	48.1	46.8	47.2

However, as soon as such companies grow, they will need new capital and share capital is often more readily available than debt-capital based on bonds, so such companies will, sooner rather than later, seek financial liquidity in stock listing and even prior to listing are likely to follow SEC reserves reporting guidelines. Investment analysts of reserve-based lending institutions want to see compliance with such reporting.

In fact, major NOCs may apply the same practice as many small US start-ups: reserves are consequent to a final investment decision for field development, declaring the resources a 'commercial asset'. However, when NOC's privatize, they must start to develop a more transparent governance system, including a reserve reporting culture and system built on concepts understood by the global community of financial analyst and investors. For example, this is why Aramco had 80% of its Dec 31, 2017 oil and gas reserves audited and certified, in November 2018, by a US consultancy firm specialized in the independent certification of oil and gas reserves. The certification letter was included in Aramco's first-ever Prospectus, released April 1, 2019, for its successful \$12 billion global bond issue.

3. Reserves management and reserves reporting systems

The Petroleum Resource Management System (PRMS) – a framework for the management and classification of reserves volumes developed by the Society of Petroleum Engineers (SPE) adopted by major professional associations (the American Association of Petroleum Geologists, the World Petroleum Council, the Society of Petroleum Evaluation Engineers, the Society of Exploration Geophysicists, the Society of Petrophysicists and Well Log Analysts and the European Association of Geoscientists and Engineers) – is globally used by oil and gas companies to classify reserves volumes (PRMS, 2007, 2018). The PRMS classification framework provides a concise set of practical instructions and definitions for the distinction of various main and sub-categories of prospective and contingent resources, as well as for the estimation of proved, probable and possible reserves. What is often misunderstood is that the PRMS is not a conclusive system for *reserves reporting*, as explained below.

The most outstanding and deliberate limitation of PRMS is that it refrains from providing any detailed instructions on how to determine whether a resource can be economically extracted. PRMS does include a clear statement that reserves are those quantities of petroleum anticipated to be *commercially recoverable* by application of development projects to known accumulations from a given date forward under defined conditions. Reserves must satisfy four criteria: they must be

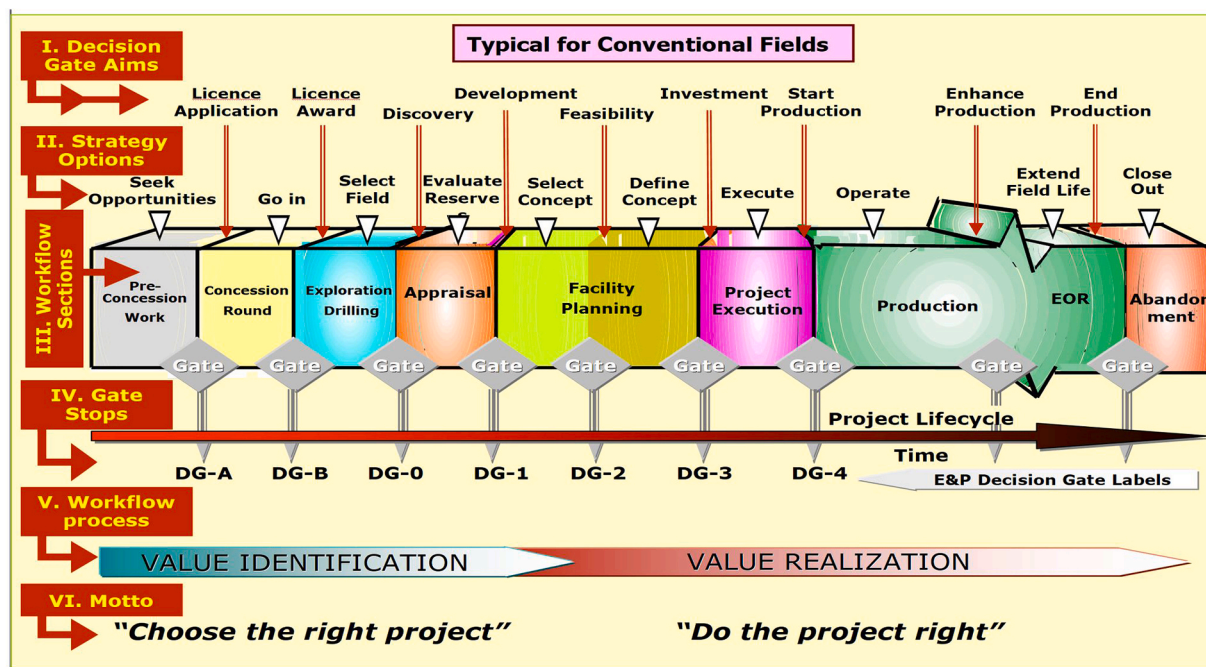


Fig. 2. Workflow architecture for development of upstream oil and gas projects. The workflow includes six attribute groups: (1) decision gate aims, (2) strategy options, (3) workflow sections, (4) decision gate stops, (5) workflow process focus, and (6) motto. Compiled from a variety of company sources (after Weijermars, 2009).

discovered, recoverable, commercial, and remaining (as of the evaluation date) based on the development project(s) applied. Reserves are further categorized into proved and unproved (probable and possible) in accordance with the level of certainty associated with the estimates (Fig. 3). Also, proved reserves may be sub-classified as undeveloped and developed, with further subdivision into developed producing and developed non-producing, all based on project maturity and/or characterized by development and production status.

In any case, what precisely determines *commercial viability* can be impacted by many factors, outside of SPE-PRMS organizational control and is much affected by the local jurisdictions where oil companies are operating. For example, a major European oil company like Shell with field assets in many continents and being dually stock-listed – both at the New York Stock Exchange and at the London Stock Exchange – will comply with the SEC reserves reporting guidelines that will affect which portion of its hydrocarbon resources may be reported as economic – as

reserves that is.

A sub-conclusion of this study is that SPE-PRMS alone cannot be used as a conclusive system for reserves reporting, because of the deliberate opacity about *commercial viability*, which must be tested according to a set of rules that may differ in different jurisdiction.

A noteworthy development is that numerous countries have resorted to the adoption of a reserves management framework proposed by the United Nations, named the United Nations Framework Classification for Resources (UNFC, 2019), rather than resorting to US-based SEC reserves reporting guidelines. Historically, the SEC has strived to emulate PRMS reserves categories, but provides a more binding set of instructions about commercial criteria, such as the mandatory use of 12-month price averages over the current reporting year forward. Similarly, the correlation between the UNFC and PRMS is considered straightforward (UNECE, 2013).

Meanwhile, the UNFC has been adopted as the basis for the national resource classification in many countries including China, India, Mexico, Poland and Ukraine. The European Commission is using the UNFC to classify and report raw material resources of Europe. Unlike PRMS, the UNFC aims to provide detailed guidance on both reserves classification and reserves reporting, meaning the rules for commercial viability are detailed. Although the UNFC itself has no authority or jurisprudence to prescribe which local set of reserves reporting guidelines and accounting principles/standards should be used in a particular nation, countries and regions that have adopted the UNFC have added their local regulation. For example, the African Union Commission has developed a UNFC-based African Mineral and Energy Resources Classification and Management System (AMREC) as a unifying system for Africa. AMREC includes a Pan-African Resources Reporting Code (PARC).

4. SEC and accounting methods affecting reserves reporting

Much of the professional global literature on reserves reporting has been dominated by US-based industry and US-based academic professionals – which explains why SEC reserves reporting guidelines are often taken as the golden standard for reserves reporting. Indeed, every

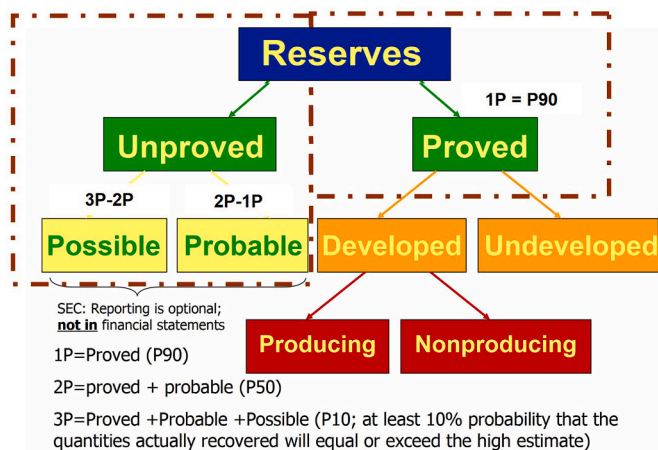


Fig. 3. Reserves are categorized in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by development and production status.

reserves estimator and reserves auditor is well advised to study in detail the SEC guidelines for reserves reporting even beyond US sovereign borders. Also, the US Internal Revenue Service (IRS) rules for depreciation, depletion and amortization (DD&A) are relevant, because of the role in reserves asset valuation that affects the balance sheet in the mandatory annual report's financial statements.

As of November 15, 2007, the SEC allows foreign companies to report financial statements and asset values using the International Financial Reporting Standards (IFRS), instead of the previously mandatory US General Accepted Accountancy Principles (US GAAP). European oil companies no longer need to reconcile IFRS data to US GAAP in their annual reporting (but Shell continues to do so in its SEC filings). For US based companies, the use of GAAP remains mandatory in SEC financial reporting (Wright and Gallun, 2008). The applied DD&A schedules must comply with the US GAAP, supported by the professional accountancy instructions of the Financial Accounting Standards Board (FASB). However, European oil and gas companies, may now chose not to report field asset values according to US GAAP as supervised by FASB (1982, 2009, 2010), and commonly prefer to use the so-called accountancy principles according to the IFRS, which are supervised by the International Accounting Standards Board (IASB).

Reserves volumes reported by a company made under a certain set of guidelines and accounting principles may somewhat differ if the same company would report under a different set of guidelines and accounting rules issued by the local jurisdiction. Some examples of the impact of differences in the US GAAP principles and IFRS standards on the value of field asset reporting are as follows. For depreciation of oil and gas property values, IFRS allows a choice to use either proved reserves or proved plus probable reserves for unit production amortization calculation. The US GAAP does not allow inclusion of probable reserves for unit of production amortization; however, cost for development of probable reserves is capitalized. Depreciation by amortization for unit of production begins when the resource is produced and thus upgraded to a proved reserve.

Effects of adopted accounting standard (US GAAP Vs IFRS) on reserves reporting and valuations are covered in a comprehensive accounting guide by PWC (2014). Full-cost accounting versus the successful efforts method is a company choice under both US GAAP and IFRS. For an oil and gas company following the full-cost accounting method, all exploration costs – including both tangible and intangible drilling costs – are capitalized by being added to the balance sheet as part of long-term assets; no depreciation applies.

Under the successful efforts method, costs relating to drilling an exploratory or exploratory-type stratigraphic well may be capitalized pending determination of whether the well has found proved reserves. If the well has found proved reserves, the drilling cost is capitalized on the balance sheet to become part of the company's wells, equipment and facilities. Depreciation occurs on the Income Statement and added back-in on the cash flow statement over the life of oil and gas properties. The cost of dry holes not contributing to the establishment of proved reserves are expensed (net of any equipment salvage value). All costs to drill and equip development type stratigraphic test wells and service wells are development costs and may be capitalized regardless of whether the well is successful or unsuccessful.

5. Saudi Aramco reserves certification

The reserves of Saudi Aramco have been published in the independently audited annual statements first released in its global prospectus published on April 1, 2019 (for 2017 and 2018). Meanwhile updated reserves statements have been included in Aramco's 2019 and 2020 annual reports (published March 2020 and March 2021, respectively). Table 1 has listed the reserves volumes with the granularity as reported by Aramco in its various public disclosures.

Noteworthy, the company's Prospectus of April 2019 included a certification letter by DeGolyer & MacNaughton (D&M) – a US based

consultancy firm, for 80% of the company reserves as per December 31, 2017. The 80% is an arbitrary portion of the Aramco reserves, a number picked by its management; one must remember that reserves certification, unlike financial audits are not mandatory in any major jurisdictions; these are optional and made on behest of the company management if they judge engaging such external auditors will boost investor trust. Consequently, D&M provided independent estimates for 80% of Aramco's proved oil, condensate, LPG, marketable gas, and oil equivalent reserves attributable to the interest owned by Saudi Arabian Oil Company in the fields evaluated as per December 31, 2017.

Aramco's FY2020 report states that D&M was also retained to evaluate for FY 2020, thus per December 31, 2019, 85% of its proven oil reserves to be produced until December 31, 2077 (pertinent to the 60-year concession period granted by the government to Saudi Aramco in 2017). Aramco's FY20 report states D&M estimations for the reservoirs it evaluated were within 1% of Aramco's internal estimations for the same reservoirs. The company stated that there is no independent third-party certification letter as at a more recent date than December 31, 2019. However, only the certification letter for 80% of the company reserves as per December 31, 2017 was previously made public. As per the date of the present study, no additional independent certification letter of Aramco reserves after December 31, 2017 has been made public.

6. Reserves reporting key assumptions

The original public reports with Aramco's reserves and field asset values – and independent 2017 audit of reserves by DeGolyer and MacNaughton and the separate audits of field asset values in the company's annual financial statements by PricewaterhouseCoopers (PWC) – were based on certain adopted assumptions as stated in their audits. For the purpose of transparency about what rules were presumed and applied in the estimation of Aramco's reserves and determination of field asset values, this section summarizes the main assumptions (explicit and implicit) as inferred from the various reports referenced.

6.1. Economic appraisal methodology

Discounted cash flow analysis is commonly used to establish whether an oil or gas field can be economically developed. Cash flow analysis models for Aramco projects, instead of using SEC (McCray, 1975; Mian, 2011) style 12-month average prices over the past production year, use Saudi government directives for forward pricing. Economic validity of conventional oil and gas field development in the Kingdom is normally no issue, as payout is commonly reached within a year or less. However, payout time may be much longer and contiguous for unconventional field development projects currently underway.

The Jafurah unconventional condensate field has been sanctioned in 2020 for full development. However, the reserve volumes appear not yet to be booked in 2020 (see time series of NGL and natural gas in Table 1). The following capitalization method is of interest (Aramco FY-20 Annual Report): *“When proved reserves of hydrocarbons are determined and there is a firm plan for development approved by management, the relevant capitalized costs are transferred to property, plant and equipment. Meanwhile, exploratory wells remain capitalized while additional appraisal drilling on the potential oil and/or gas field is performed or while optimum development plans are established. All such capitalized costs are not subject to amortization, but at each reporting date are subject to regular technical and management review to confirm the continued intent to develop, or otherwise extract value from the well. Where such intent no longer exists, the costs are immediately written off to exploration in the Consolidated Statement of Income. Capitalized exploratory expenditures are not subject to amortization but, at each reporting date, are subject to review for impairment indicators.”* One may assume that the actualization and reflection of Jafurah field development in reserves growth will appear in the company's future annual reports.

6.2. Fiscal regime

In the US, the Internal Revenue Service (IRS) provides detailed instructions to oil and gas companies on how to apply depreciation rules when reporting reserves asset values for federal taxation of corporate income (IRS, 2013, 2016). Additionally, production taxes and property taxes must be paid to the states where the companies operate, and royalties are due to the private landowner that leases the right to produce. For example, a Bakken case study, showed how field development is affected by tax regimes varying across the three states where the reservoir is being developed (Weijermars et al., 2017).

In Saudi Arabia, fiscal policies pertinent to royalties and taxation of oil and gas profits from certain fields as well as corporate income tax are adjusted from time to time by the government. Relevant changes pertinent to Aramco's valuation of (new) field development projects are specified in Saudi Aramco's annual reports under "Recent fiscal regime changes", as well as under "Royalty and Taxes" and "Regulated domestic pricing of certain hydrocarbons". At the same time, the company is compensated by the government for revenue directly foregone as a consequence of domestically supplying regulated gas products, in the event that government established prices do not meet the relevant price determined to achieve the rate of return approved by the government for the company's gas products. However, what rate of return is actually approved was not publicly announced.

A sub-conclusion is that the fiscal regime applicable to Aramco's revenues from field operations and used for valuation of field assets and reserves are contiguous to periodic adjustments of government policies.

6.3. Accounting principles

Impairment of Aramco's oil and gas property (reserves), it was stated in the audit letter of PricewaterhouseCoopers (PWC) are based on valuation models using discounted cash flows, assuming certain price scenarios, production rates, capital and operating expenditures, and abandonment costs. It was also stated that IFRS accounting rules were applied and are supported by the Saudi Organization for Certified Public Accountants (SOCPA). PWC asserted SOCPA adheres to IASB guidelines. Sharia's compliant financial instruments of the company are disclosed separately. Aramco's exploration and evaluation cost are recorded under the successful efforts method of accounting. Historic cost convention is adopted in the consolidated financial statements. The company uses for depreciation of oil and gas field a unit of production method, unless the field life is expected to substantially exceed the economic or technical life of the underlying asset. In the latter cases, a straight-line method of depreciation is assumed. Permissible depreciation timelines (years) for specific assets are given in the PWC explanatory notes of Aramco's annual reports.

6.4. Reserves aggregation

Several technical options for reserves aggregation exist. For example, SEC allows the use of probabilistic reserves aggregation at field asset level but mandates deterministic aggregation by arithmetic addition beyond field level. The method of aggregation may substantially affect the reserves estimation outcome (SPEE, 2010). It is known that deterministic (unlike probabilistic) methods may substantially underestimate proved reserve volumes. Consequently, it would be useful if a regulatory agency would specify the permissible aggregation method to be used in the compilation and reporting of oil and gas reserves in Saudi Arabia.

6.5. Reserves valuation

Valuations of the remaining production from proved reserves are mandatory according to SEC reserves reporting guidelines applicable to company's stock-listed on the US NYSE. Oil and gas operators, under SEC rules, must report and value proved reserve volumes. Reporting of

probable and possible reserves is optional; and no valuation may be included in the annual report of probable and possible reserves. The value of proved reserves must be computed based on production forecasts of produced monthly volumes with a discounted cash flow model. Forward use of 12-month average prices of the current year is mandatory, as well as a 10 percent discount rate of future cash flows to compute the present value at the time of reporting. The value reported is after subtracting all mandatory taxes (production taxes, property taxes, project profit taxes as part of corporate profit taxes).

For comparison, companies operating under Canadian jurisdiction must report in their annual reports the value of both proved and probable reserves, while using forward inflated product prices, undiscounted and before taxation. For investment analysts it would be very useful if a Saudi regulatory agency would specify the permissible valuation method to be used in the valuation of reported oil and gas reserves. Such valuations are currently not included in the annual reports of Saudi Aramco.

7. Discussion

Aramco's 2019 IPO prospectus and the subsequent FY 2019 and 2020 Annual Reports stated that PRMS was used in reserves estimations, but as was pointed out in Section 3 of this study, the reserves management system was primarily designed for internal management of hydrocarbon reserves. Additional reporting guidelines and auditing by a relevant agency (such as SEC) are commonly issued. In the case of Aramco reserves reporting, the rules that apply to the commercial benchmarking of the stated reserves are understood to be stemming from Saudi government policy as issued via the Ministry of Energy, but no formally published reserves reporting guidelines currently exist, which leaves several key issues contiguous. Some clues on what parameters were adopted in Aramco's reserves estimations appeared as stated assumptions in the independent reserves certification letter of D&M, not as an explicit set of regulatory guidelines provided prior to – and separate from – the reserves estimation, as is customary for publicly traded oil and gas companies elsewhere (such as the SEC reserves reporting guidelines).

Table 4 compiles the common choices regarding the guidelines and methods followed in reserves reporting, and those adopted in Saudi Arabia as it appears from comments and notes in Saudi Aramco's annual reports and the independent audits of reserves by DeGolyer and MacNaughton and of the field asset values and financial statements by PricewaterhouseCoopers (PWC).

Based on the analysis of Section 6 and summary in Table 4, it could be inferred that Aramco's reserves and valuation of the assets is partly based on international frameworks and partly adjusted by Saudi

Table 4

Choices for guidelines and methodologies followed in reserves reporting.

Governance Topic	Methods and organizations	Aramco/Saudi Arabia
Company internal reserves management system	PRMS is the industry standard	PRMS
Principal reserves reporting system	SEC, UNFC or publicized national regulation	not specified
Principal accounting system	GAAP or IFRS	IFRS
Principal overseeing bodies	FASB or IASB	IASB and SOCPA
Principal capitalization methods	Successful Efforts or Full Cost	Successful Efforts
Principal depreciation system	Straight line or unit of production	Straight line and unit of production
Fiscal system	National regulation, like IRS type directives for depreciation methods (DD&A)	not specified

government policy incentives. A striking example of such policy incentives is apparent from the stated price assumptions in DeGolyer and MacNaughton's (D&M) certification letter. The price assumptions in the economic evaluation of the reserves volumes of Saudi Aramco (as per Dec 31, 2017 in the D&M certification letter) used forward prices of \$3.84/MMBTU ~ (Mcf; after 2020) for the non-associated gas produced in the northern area, and \$1.52/MMBTU ~ (Mcf) for the non-associated gas produced in the southern area, with co-produced Ethane prices of \$14.45/bbl in the northern area and \$7.30/bbl in the southern area. The adoption of such future price policies is not permissible under SEC reserves reporting guidelines, which instead mandates the use of 12-month price averages from the current reporting year forward.

Of course every sovereign nation has the right to determine its own reserves reporting guidelines; the key concern raised here is that an independent regulatory public authority issuing reporting guidelines for reserves reporting, comparable to US SEC guidelines, does not yet exist in Saudi Arabia. Fiscal policies made public for capitalization and depreciation of assets, similar to US IRS guidelines, also would bring more transparency required for international investment analysts to understand the basis of reported asset values in the financial statements. Meanwhile, it is understood from the PWC explanatory notes in recent annual reports of Aramco that the company uses IFRS accounting principles and not GAAP (Table 4).

In addition, Aramco's 2019 Annual Report provides the following pertinent information and clauses on its reserve reporting: *"Saudi Aramco's estimates of the quantity of its proved hydrocarbon reserves depend on significant interpretations, assumptions and judgments relating to available geological, geophysical, engineering, contractual, economic and other information, and take into account existing economic and operating conditions and commercial viability as at the date the reserve estimates are made. There can be no assurance that the interpretations, assumptions and judgments utilized by Saudi Aramco to estimate proved reserves will prove to be accurate. Any significant deviation from these interpretations, assumptions or judgments could materially affect the estimated quantity or value of Saudi Aramco's proved reserves. In addition, these estimates could change due to new information from production or drilling activities, changes in economic factors, including changes in the price of hydrocarbons, changes to laws, regulations or the terms of the Concession or other events. Further, declining hydrocarbon prices may cause certain proved reserves to no longer be considered commercially viable, which could result in downward adjustments to Saudi Aramco's estimates of its proved reserves, impairment of its assets or changes to Saudi Aramco's capital expenditures and production plans."*

All of the above conforms to what is commonly found in the annual reports of other major oil companies. However, then the report states: *"Moreover, proved reserves estimates are subject to change due to 'changes in published rules or changes in guidelines'.* Any material reduction in the quantity or value of Saudi Aramco's proved reserves could affect its business." However, no Saudi sovereign agency has emerged where reserves reporting rules and guidelines or *'changes in published rules or changes in guidelines'* are publicly announced prior to the actual reserves reporting by any company active in the Kingdom.

Finally, an important leverage of the Saudi government on Aramco's depletion rate of its oil reserves is that the government determines the Kingdom's maximum level of crude oil production. In the exercise of its sovereign prerogative, the government requires Aramco to maintain a potential supply capacity that was increased in FY-2020 from 12.0 to 13.0 million barrels per day. Notwithstanding, Saudi Aramco's operating segments are established on the basis of those components that are evaluated regularly by the CEO, who is considered to be the Chief Operating Decision Maker. As such, the CEO monitors the operating results of Saudi Aramco's operating segments separately for the purpose of making decisions about resource allocation and performance assessment. Segment performance is evaluated based on revenues, costs and a broad range of key performance indicators in addition to segment profitability.

8. Conclusions and recommendations

Saudi Aramco started the implementation of its privatization process by bond issues and flotation a minor portion of shares in 2019. The global community of energy investment analysts must now examine and advise their banks and investment fund managers on the soundness of operational fundamentals, asset base and financial performance of Saudi Aramco. This includes a review of the reported reserves which requires transparency about the guidelines and procedures based on which these have been estimated. Because Saudi Arabia has a production capacity amounting to 12–13% of global daily supply and harnesses some of the largest conventional and unconventional hydrocarbon reserves, precise volumetric estimates and valuation of its reserves are key for private investors and energy strategy analysts.

To better understand the basis of Aramco's reserves estimations and valuation, and any future changes thereto, the following steps were completed in our study:

- Reserves reporting framework in Saudi Arabia was reviewed.
- Saudi Aramco's reserves reporting methods were analyzed.
- Some ambiguity in reporting guidelines was identified.
- Recommendations for regulatory improvement were specified.

For Saudi Arabia, like in any other nation guiding a national oil company toward privatization, the development of a governance system aimed at increasing the transparency about the regulatory framework of published rules and guidelines for reserves reporting is recommended. The global community of financial analysts and investors will be looking for such transparency, and hints for creating further improvements to the emergent transparency are given in Sections 6 and 7 of the present study. A main conclusion is that higher transparency in the Kingdom's reserves reporting governance will help the global investor community better value the company. Higher governance transparency will directly translate into higher liquidity in the trading of Aramco stocks, and increased interest in the future issuance of either new shares and/or new bond issues. Reduction in informational gaps will benefit shareholders, including the Saudi government treasury and PIF, the government-controlled sovereign wealth fund of Saudi Arabia. These objectives are in line with Vision 2030, the strategic transformation plan for Saudi Arabia (Vision, 2021).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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This study was conducted as part of ongoing research and a new professional master program, including reserves estimation and production forecasting methods, developed at King Fahd University of Petroleum & Minerals (KFUPM) to meet the future needs of the oil industry, government agencies, and investment firms. The requirements for reserves reporting guidelines and regulatory framework detailed in this study provide a basis for technical evaluation of various field development projects. Although there is no direct technical component in this paper, resolving some of the ambiguity concerning reserves reporting is of great importance for decision path optimization in field development projects.

Acronyms

AMREC	African Mineral and Energy Resources Classification and Management System
CEO	Chief Executive Officer

DD&A	Depreciation, depletion and amortization
D&M	DeGolyer and MacNaughton's
DG	decision gate
FASB	Financial Accounting Standards Board
FY	Fiscal Year
GAAP	General Accepted Accountancy Principles
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
IPO	initial purchase offering
IRS	Internal Revenue Service
KFUPM	King Fahd University of Petroleum & Minerals
LPG	liquefied petroleum gas
Mcf	million cubic feet
MMBTU	million British thermal units
NGL	Natural Gas Liquids
NOC	National Oil Company
NYSE	New York Stock Exchange
OPEC	Organization of Petroleum Exporting Countries
PARC	Pan-African Resources Reporting Code
PIF	Public Investment Fund
PRMS	Petroleum Resource Management System
PWC	PricewaterhouseCoopers
SEC	Securities and Exchange Commission
SPE	Society of Petroleum Engineers
SPEE	Society of Petroleum Evaluation Engineers
SOCPA	Saudi Organization for Certified Public Accountants
UNFC	United Nations Framework Classification for Resources
US	United States

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